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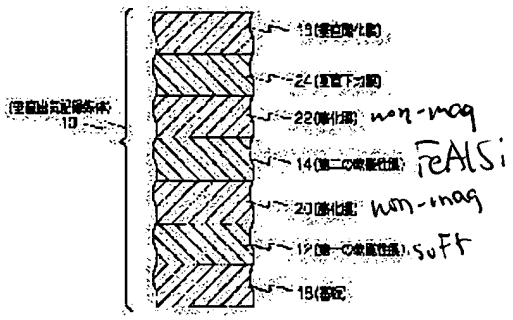
(54) PERPENDICULAR MAGNETIC RECORDING MEDIUM

(57)Abstract:
PROBLEM TO BE SOLVED: To improve noise characteristics and envelope characteristics in recording and reproducing and to improve recording and reproducing characteristics with high recording density.
SOLUTION: This perpendicular magnetic recording medium 10 consists of a first soft magnetic film 12 having 1 to 100Oe coercive force, a second soft magnetic film 14 comprising a Sendust film and a perpendicular magnetization film 16 successively formed in this order on a substrate 18. By forming the soft magnetic film 12 having about 1 to 100Oe coercive force between the substrate 18 and the second soft magnetic film 14, magnetic domains in the soft magnetic film 14 hardly move, which improves noise characteristics. By forming oxide films 20, 22, on and under the soft magnetic film 14, fluctuation in the compsn. or distribution of the compsn. of FeSiAl can be suppressed.



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* NOTICES *

1. This document has been translated by computer.So the translation may not reflect the original precisely.
2. **** shows the word which can not be translated.
3.In the drawings, any words are not translated.

CLAIMS

[Claim(s)]
[Claim 1] The vertical-magnetic-recording medium by which the first soft-magnetism film which has the coercive force of 1-100Oe, the second soft-magnetism film which consists of a Sendust film, and perpendicular magnetic anisotropy films were formed on the substrate at this order.
[Claim 2] The vertical-magnetic-recording medium according to claim 1 which the aforementioned substrate is aluminum alloy substrate and is the NiP film with which the soft-magnetism film of the above first was formed on the aforementioned aluminum alloy substrate.
[Claim 3] The vertical-magnetic-recording medium according to claim 1 or 2 by which Cr film was inserted between the soft-magnetism film of the above first, and the soft-magnetism film of the above second.
[Claim 4] The vertical-magnetic-recording medium according to claim 1, 2, or 3 by which the oxide film was inserted in the upper and lower sides of the soft-magnetism film of the above second, respectively.
[Claim 5] It is Co1-x Crx directly under the aforementioned perpendicular magnetic anisotropy films.
Vertical-magnetic-recording medium according to claim 1, 2, 3, or 4 by which the perpendicular ground film which consists of a film (0.25<=x<=0.60) was inserted.
[Claim 6] The vertical-magnetic-recording medium according to claim 5 by which the perpendicular ground film containing CoCr beyond 85at% was inserted directly under the aforementioned perpendicular magnetic anisotropy films.

[Translation done.]

DETAILED DESCRIPTION

[Detailed Description of the Invention]
[0001]
[The technical field to which invention belongs] this invention relates to the vertical-magnetic-recording medium used as a magnetic tape, a magnetic disk, etc.
[0002]
[Description of the Prior Art] In recent years, as for the magnetic disk, the further high surface density-ization is desired by large-capacity-izing and the miniaturization of a hard disk drive accompanying progress of a personal computer or a workstation. However, if the longitudinal recording method which has spread widely now tends to realize densification, the problem magnetization / record / accompanying detailed-izing of a record bit] of heat fluctuation and the problem of a raise in coercive force exceeding the record capacity of a recording head will occur. Then, the vertical recording method is examined as a means which can improve field recording density sharply, solving these problems. There is a perpendicular two-layer medium which consists of a soft-magnetism film of high permeability and perpendicular magnetic anisotropy films of a high perpendicular anisotropy as one of the vertical-magnetic-recording media which realizes this.
[0003] Drawing 21 is the outline cross section showing the conventional example of such a vertical-magnetic-recording medium.

[0004] As for this vertical-magnetic-recording medium 50, the soft-magnetism film (backing layer) 52 and perpendicular magnetic anisotropy films 54 are formed on a substrate 56 at this order. For example, as a soft-magnetism film 52, a CoCr system alloy film is used as a NiFe film and perpendicular magnetic anisotropy films 54 (the Magnetics Society of Japan, Vol.8, No 1 and 1984, p17).
[0005] However, when the perpendicular magnetic anisotropy films 54 which consist of a soft-magnetism film 52 which consists of NiFe, and CoCr are formed, the fall of the crystal amount of preferred orientation of perpendicular magnetic anisotropy films 54 occurs. Then, in order to prevent this, what used the Sendust film (FeSiAl alloy) as a soft-magnetism film 52 is reported (JP,57-36435,A).
[0006]
[Problem(s) to be Solved by the Invention] However, when such a Sendust film is used, the following problems newly arise.
[0007] The 1st problem is the point that the noise figure in the case of record reproduction is bad. To tend to make the magnetic domain of a Sendust soft-magnetism film, and the reason is easy to move the magnetic domain.
[0008] The 2nd problem is the point that the envelope property in the case of record reproduction is bad. Since the reason has large composition change or composition distribution of a Sendust film, it is because the variation in the magnetic properties in a circumferencial direction becomes very large.
[0009] The 3rd problem is the point that the record reproducing characteristics in high recording density are bad. The perpendicular magnetic anisotropy films which could not say above that the reason of the ********** of a Sendust film was enough, and formed membranes on the Sendust film are because the stacking tendency is bad.
[0010]
[Objects of the Invention] The purpose of this invention is to offer the vertical-magnetic-recording medium which raised the noise figure at the time of record reproduction, an envelope property, and the record reproducing characteristics in high recording density.
[0011]
[Means for Solving the Problem] The first soft-magnetism film with which a vertical-magnetic-recording medium according to claim 1 has the coercive force of 1-100Oe, the second soft-magnetism film which consists of a Sendust film (FeSiAl film), and perpendicular magnetic anisotropy films are formed on a substrate at this order. It is hard coming to move the magnetic domain of the second soft-magnetism film with this first soft-magnetism film.
[0012] In a vertical-magnetic-recording medium according to claim 1, the aforementioned substrate is aluminum (aluminum) alloy substrate, and a vertical-magnetic-recording medium according to claim 2 is the NiP (nickel Lynn) film with which the soft-magnetism film of the above first was formed on the aforementioned aluminum alloy substrate. Hereafter, this is indicated to be an "NiP/aluminum alloy substrate." The coercive force of 1-100Oe can be given to a NiP film by heat-treating and carrying out magnetization of this NiP/aluminum alloy substrate.
[0013] In a vertical-magnetic-recording medium according to claim 1 or 2, as for a vertical-magnetic-recording medium according to claim 3, Cr (chromium) film is inserted between the soft-magnetism film of the above first, and the soft-magnetism

film of the above second. With this Cr film, the adhesion force of the first soft-magnetism film and the second soft-magnetism film increases.
[0014] In a vertical-magnetic-recording medium according to claim 1, 2, or 3, as for a vertical-magnetic-recording medium according to claim 4, an oxide film is inserted in the upper and lower sides of the soft-magnetism film of the above second, respectively. The second composition change or composition distribution of a soft-magnetism film is suppressed by this oxide film.
[0015] It sets to a vertical-magnetic-recording medium according to claim 1, 2, 3, or 4, and a vertical-magnetic-recording medium according to claim 5 is Co1-x Crx directly under the aforementioned perpendicular magnetic anisotropy films. The perpendicular ground film which consists of a film (0.25<=x<=0.60) is inserted. With this perpendicular ground film, the perpendicular stacking tendency of perpendicular magnetic anisotropy films improves.
[0016] The perpendicular ground film with which a vertical-magnetic-recording medium according to claim 6 contains CoCr beyond 85at% directly under the aforementioned perpendicular magnetic anisotropy films in a vertical-magnetic-recording medium according to claim 1, 2, 3, or 4 is inserted. With this perpendicular ground film, the perpendicular stacking tendency of perpendicular magnetic anisotropy films improves.
[0017]
[Embodiments of the Invention] Drawing 1 is the outline cross section showing 1 operation gestalt of the vertical-magnetic-recording medium concerning this invention.
[0018] The first soft-magnetism film 12 with which the vertical-magnetic-recording medium 10 concerning this operation gestalt has the coercive force of 1-100Oe, the second soft-magnetism film 14 which consists of a Sendust film, and perpendicular magnetic anisotropy films 16 are formed on a substrate 18 at this order. Since it is hard coming to move the magnetic domain of the soft-magnetism film 14 between a substrate 18 and the second soft-magnetism film 14 by inserting the soft-magnetism film 12 whose coercive force is about 1-100 Oes, noise figure improves.
[0019] Moreover, composition change or a composition distribution of FeSiAl can be suppressed by forming oxide films 20 and 22 in the upper and lower sides of the soft-magnetism film 14.
[0020] Furthermore, it is Co1-x Crx of high Cr concentration directly under perpendicular magnetic anisotropy films 16. By forming the perpendicular ground film 24 which consists of a film (0.25<=x<=0.60), the perpendicular stacking tendency of perpendicular magnetic anisotropy films 16 can be raised remarkably.
[0021] Below, the example of this invention is shown. The vertical-magnetic-recording medium only applied to a "medium" and this invention in a vertical-magnetic-recording medium will be called [hereafter,] "this invention medium", and the conventional vertical-magnetic-recording medium will be called "conventional medium."
[0022]
[Example 1] 5 micrometers of NiP soft-magnetism films of coercive force 20Oe were produced with plating on the 2.5 inches glass substrate. Next, 0.1-5.0 micrometers of Sendust films were formed by the spatter using the Fe83Si11.6aluminum5.4 target (at%) of 6 inch phi. Membrane formation conditions were made into 0.5kW of injection power, argon gas ** 4mTorr, and membrane formation speed 3 nm/sec in initial degree of vacuum 5x10-7mTorr. Then, this medium was annealed at 400 degrees C for 1 hour.
[0023] The Sendust thickness dependency of the coercive force of the Sendust film after annealing is shown in drawing 2 . For comparison, on a 2.5 inches glass substrate, a Sendust film is formed directly, and is set and shown also about a medium conventionally which annealed. As for this invention medium, a medium shows conventionally that ********** is excellent under the influence of the NiP soft-magnetism film which is in the lower layer of a Sendust film from this.
[0024] Moreover, NiP and 5 micrometers of Sendust thickness of coercive force 20Oe were formed upwards, and 100nm (at%) of Co80Cr17Ta3 perpendicular magnetic anisotropy films was formed by the spatter. Membrane formation conditions were made into 0.5kW of injection power, argon gas ** 4mTorr, and membrane formation speed 3 nm/sec in initial degree of vacuum 5x10-7mTorr. Thus, let the produced this invention medium be Medium A. For comparison, a Sendust film is directly formed on a substrate, and let a medium be Medium B conventionally which produced perpendicular magnetic anisotropy films like Medium A.
[0025] It experimented in the record reproduction by the ID/MR combined head of Medium A and Medium B. Here, for recording track width of face, 4 micrometers and regenerative-track width of face are [0.4 micrometers and the reproduction gap length of 3 micrometers and record gap length] 0.32 micrometers. Evaluation was performed under conditions of record current 10mAop, 12mA of sense current, peripheral-velocity 12.7 m/s, 45nm of flying heights, and 45MHz of band bands of a noise.
[0026] The recording density dependency of a medium noise is shown in drawing 3 . Conventionally, compared with Medium B, the medium noise of this invention medium A is small, and it turns out that noise figure is very excellent. That is, instability of the magnetic domain of a Sendust film was suppressed and formed into the low noise by existence of the NiP soft-magnetism layer of coercive force 20Oe.
[0027] The recording density dependency of a reproduction output signal is shown in drawing 4 . Medium B shows an equivalent property this invention medium A and conventionally.
[0028] The recording density dependency of medium S/N is shown in drawing 5 . 2-3dB of medium S/N is good, and this shows [in / all recording density / medium / conventionally / in this invention medium] excelling as a magnetic-disk medium of high-density correspondence. Therefore, realization of high recording density becomes easy by using this invention medium.
[0029] In addition, the result same also about the medium of 0.1-3 micrometers of Sendust thickness shown in drawing 2 as the case of the 5 micrometers of the above-mentioned Sendust thickness was obtained. That is, according to this invention medium,

the medium noise in comparison with a medium was conventionally small, and since medium S/N was excellent, realization of high-density record became easy.
[0030]
[Example 2] On the 2.5 inches glass substrate, 2 micrometers of NiP soft-magnetism films of coercive force 100Oe were produced with plating. Then, like the example 1, membrane formation and after annealing, 50nm of Co80Cr20 (at%) perpendicular magnetic anisotropy films was formed for 2 micrometers of Sendust films. In addition, it is the same as an example 1 except [all] composition and thickness of the thickness of a NiP film, the thickness of a Sendust film, and perpendicular magnetic anisotropy films. Thus, both were 2Oe(s) when the coercive force of the Sendust film of Medium D was measured the obtained this invention medium C and conventionally. Record reproduction was evaluated for Medium D like the example 1 this invention medium C and conventionally.
[0031] The recording density dependency of a medium noise is shown in drawing 6 . this invention medium C has a conventionally small medium noise compared with Medium D, and it turns out that noise figure is very excellent. That is, it turns out that the instability of the magnetic domain of a Sendust film was suppressed by existence of the NiP soft-magnetism layer of coercive force 100Oe, and the low noise was formed.
[0032] In addition, the record density dependence of the output of both media did not have a difference as well as an example 1. This showed this invention medium which has the NiP soft-magnetism film of coercive force 100Oe having the work which can suppress a medium noise, with a reproduction output maintained, and excelling very much as a magnetic disk of high-density correspondence.
[0033]
[Example 3] Coercive force was set to 40Oe(s) when annealing and carrying out magnetization of the 3.5 inches NiP/aluminum alloy substrate at 350 degrees C. On this substrate, a Sendust film and perpendicular magnetic anisotropy films were formed completely like the example 2. Thus, let the obtained this invention medium be Medium E. A Sendust film and perpendicular magnetic anisotropy films were formed one by one on the conditions same as an example of comparison as having produced Medium E on the 3.5 inches NiP/aluminum alloy substrate. Thus, let a medium be Medium F conventionally which was obtained.
[0034] Record reproducing characteristics were evaluated for Medium E and Medium F like the example 1. The recording density dependency of a medium noise is shown in drawing 7 . The medium noise of the medium F conventional by 100 or more kFRPIs of recording density becomes large rapidly. On the other hand, it turns out that the medium noise of the medium E of this invention is reduced compared with Medium F.
[0035] Although the NiP/aluminum alloy substrate was annealed at 350 degrees C and used as a soft-magnetism film of coercive force 40Oe in this example, the same result was obtained even if it changed the annealing temperature among 250-500 degrees C.
[0036]
[Example 4] On the 2.5 inches glass substrate, 1 micrometer of Fe soft-magnetism films of coercive force 5Oe was produced by the spatter. After forming 0.1 micrometers of Cr films on this Fe soft-magnetism film, 0.5 micrometers of Sendust films were produced like the example 1. Thus, the produced this invention medium was used as Medium G. After forming direct Sendust film 0. and 5 micrometers on a glass substrate, without attaching Cr film as an object for comparison, Medium H was produced conventionally similarly.
[0037] The adhesion force of Medium H was measured this invention medium G and conventionally. Consequently, the adhesion force of Medium G was 110MPa(s), and the adhesion force of Medium H was 40MPa(s). That is, Cr adhesion layer shows that adhesion force is improving extremely. Therefore, the mechanical endurance of a vertical-magnetic-recording medium improved greatly according to the structure of preparing Cr adhesion layer between the Sendust film of this invention medium, and a soft-magnetism film (Fe film in this case).
[0038] Moreover, the result which measured record reproducing characteristics for these media like the example 1 is shown in drawing 8 . It turns out that the medium noise of this invention medium G is small in all recording density compared with Medium H conventionally. Therefore, this invention medium showed the record reproducing characteristics which were excellent while mechanical endurance went up.
[0039]
[Example 5] On the 3.5 inches NiP/aluminum alloy substrate, 1 micrometer of FeCo soft-magnetism films of coercive force 70Oe was produced by the spatter. After forming 0.2 micrometers of Cr films on this nickel soft-magnetism film, 1 micrometer of Sendust films was produced like the example 1. Thus, the produced this invention medium was used as Medium I. Moreover, after forming 1 micrometer of direct Sendust films on an NiP/aluminum alloy substrate as an object for comparison, without attaching Cr film, Medium J was produced conventionally similarly.
[0040] The adhesion force of Medium J was measured this invention medium I and conventionally. Consequently, the adhesion force of Medium I was 105MPa(s), and the adhesion force of Medium J was 25MPa(s). That is, Cr adhesion layer shows that adhesion force is improving greatly. Therefore, it became clear that the mechanical endurance of a medium improves greatly according to the structure of preparing Cr adhesion layer between the Sendust film of this invention, and a soft-magnetism film (FeCo film in this case).
[0041] Moreover, the result which measured record reproducing characteristics for these media like the example 1 is shown in drawing 9 . It turns out that the medium noise of this invention medium I is small in all recording density compared with Medium J conventionally. Therefore, this invention medium shows the record reproducing characteristics which were excellent while

mechanical endurance went up.
[0042] Although this example showed the result which used the 1-micrometer FeCo soft-magnetism film, if Cr adhesion layer is used, while the adhesion force improves similarly by the NiP substrate which annealed [film / NiP soft-magnetism], record reproducing characteristics will improve.
[0043]
[Example 6] On the 3.5 inches NiP/aluminum alloy substrate, 0.5 micrometers of FeSi soft-magnetism films of coercive force 1Oe were produced by the spatter. On this FeSi soft-magnetism film, they are 0.1 micrometers and aluminum 2O3 about Cr film. They are 0.5 micrometers and aluminum 2O3 about 0.2 micrometers and a Sendust film in a film. this invention medium which formed 0.2 micrometers one by one and produced the film was used as Medium K. The medium was used as Medium L conventionally which formed 0.5 micrometers of direct Sendust films on the substrate on the same conditions as an object for comparison. In addition, Medium K and Medium L were annealed at 400 degrees C for 1 hour, in order to take out the ********** of a Sendust film. Furthermore, similarly, it annealed for 1 hour and 300 degrees C of media N were produced this invention medium M and conventionally.
[0044] The result which performed the component analysis of the Sendust film of the obtained medium is shown in drawing 10 and drawing 11 . The medium L of a medium and Medium N have [the medium K of this invention medium, and Medium M] the very large gap from target composition conventionally to a thing with the small gap from target composition. This will be considered for composition to change by movement of an atom becoming active into annealing, and passing a substrate side, or moving from a substrate side, if there is no oxide film (aluminum2 O3 film in this case). By this invention medium, since a stable oxide film is in the upper and lower sides of a Sendust film, composition change hardly takes place. Therefore, after forming an oxide film to the upper and lower sides of a Sendust film, this invention medium which carried out the laminating of the perpendicular magnetic anisotropy films shows stable record reproducing characteristics.
[0045]
[Example 7] On the 3.5 inches glass substrate, 2 micrometers of FeCo soft-magnetism films of coercive force 10Oe were produced by the spatter. On this FeCo soft-magnetism film, they are 0.2 micrometers and SiO2 about Cr film. They are 1 micrometer and SiO2 about 0.1 micrometers and a Sendust film in a film. this invention medium which formed 0.1 micrometers one by one and produced the film was used as Medium O. The medium was used as Medium P conventionally which formed 1 micrometer of direct Sendust films on the substrate on the same conditions as an object for comparison. In addition, Medium O and Medium P were annealed at 400 degrees C for 1 hour, in order to take out the ********** of a Sendust film.
[0046] The distribution of the component analysis of the Sendust film of the obtained medium was measured. The circumferencial direction of this invention medium O and drawing 13 show a composition distribution [in / radial / of Medium P / conventionally / drawing 12 / the circumferencial direction of Medium P, and drawing 14 , and / in drawing 15] in radial / of this invention medium O / conventionally. A circumferencial direction is the result of measuring four points to four points and radial every 90 degrees. Medium P has [the medium O of this invention medium] a very large composition distribution conventionally to a thing with a small composition distribution. if this does not have an oxide film (SiO2 film in this case) -- the inside of annealing -- movement of an atom -- active -- becoming -- a substrate side -- or it thinks for an atom to move from a substrate side (When perpendicular magnetic anisotropy films are on a Sendust film, it moves also in the direction of perpendicular magnetic anisotropy films.) Since the movement is also random, a partial composition change is large again. On the other hand, by this invention medium which has a stable oxide film in the upper and lower sides of a Sendust film, composition change hardly takes place. Therefore, after forming an oxide film to the upper and lower sides of a Sendust film, this invention medium which carried out the laminating of the perpendicular magnetic anisotropy films shows stable record reproducing characteristics.
[0047] Although this example showed the result in case there is a Cr adhesion layer, the same effect is acquired even if there is no Cr adhesion layer.
[0048]
[Example 8] On the 2.5 inches glass substrate, 0.5 micrometers of FeCo soft-magnetism films of coercive force 15Oe were produced by the spatter. On this FeCo soft-magnetism film, it is aluminum 2O3. They are 0.5 micrometers and aluminum 2O3 about 0.2 micrometers and a Sendust film in a film. this invention medium which formed 0.2 micrometers one by one and produced the film was used as Medium Q. The medium was used as Medium R conventionally which formed 0.5 micrometers of direct Sendust films on the substrate on the same conditions as an object for comparison. In addition, after annealing Medium Q and Medium R at 450 degrees C for 15 hours, they formed 100nm of perpendicular magnetic anisotropy films like the example 1.
[0049] Record reproducing characteristics were evaluated for these media like the example 1. The envelope property of Medium Q and Medium R is shown in drawing 16 . this invention medium Q is understood that an envelope property is very good to a thing with the conventionally bad envelope property of Medium R. Conventionally, since composition change and a composition distribution of a Sendust film were large, since composition change and a composition distribution of a Sendust film were suppressed by existence of an oxide film (it is aluminum2 O3 film in this case) to a thing with a bad envelope property, the envelope property of Medium R improved greatly as for this invention medium Q.
[0050]
[Example 9] On the 2.5 inches glass substrate, 0.5 micrometers of FeCo soft-magnetism films of coercive force 3Oe were produced by the spatter. On this FeCo soft-magnetism film, it is aluminum 2O3. They are 0.1 micrometers and aluminum 2O3 about 1 micrometer and a Sendust film in a film. this invention medium which formed 1 micrometer one by one and produced the

film was used as Medium S. The medium was used as Medium T conventionally which formed 1 micrometer of direct Sendust films on the substrate on the same conditions as an object for comparison. In addition, Medium S and Medium T were annealed at 350 degrees C for 1 hour in order to raise **********. Similarly, Medium V was produced this invention medium U and conventionally by carrying out 450-degree-C annealing of 1 hour.

[0051] Change of the magnetic properties of the circumferencial direction of these media was measured in the disk radius position of 25mm, making it change to a circumferencial direction by a unit of 1 time. Change of the coercive force of a circumferencial direction is shown in drawing 17 about Medium T this invention medium S and conventionally. Change of the coercive force of a circumferencial direction is shown in drawing 18 about Medium V this invention medium U and conventionally.

[0052] Conventionally, since composition change and the composition distribution are large, and, as for this invention medium S and Medium U, composition change and a composition distribution are suppressed to one with a very sharp change of the coercive force of a circumferencial direction, as for Medium T and Medium V, change of the coercive force of a circumferencial direction is very small. That is, property dispersion, such as a reproduction output and a medium noise, can be reduced by producing this invention medium using a Sendust film with little dispersion in magnetic properties.

[0053]

[Example 10] By carrying out lamp heating of the 3.5 inches NiP/aluminum alloy substrate, magnetization of the NiP was carried out to coercive force 35Oe. It is SiO2 on this substrate. 2 micrometers of films, 0.5 micrometers of Sendust films, and SiO2 2 micrometers of films, Co65Cr35 (at%) 50nm, and Co76Cr19Ta5100(at%) nm were formed one by one. Thus, the produced this invention medium was used as Medium W. For comparison, 0.5 micrometers and Co76Cr19Ta5100(at%) nm were formed for the Sendust film one by one on the 3.5 inches NiP/aluminum alloy substrate. Thus, the medium was used as Medium X conventionally which was produced.

[0054] In order to investigate the crystal stacking tendency of these media, the X diffraction was used and it asked for the half-value width (**theta50) of the rocking curve of a hcp (002) peak. Consequently, it turns out conventionally to Medium X being 7 times that this invention medium is 2 times and the crystal stacking tendency is excellent.

[0055] Co76Cr19Ta5 which is conventionally in contact with the Sendust film by the medium Not perpendicular magnetic anisotropy films with a perfect film but a 10 to about 20nm initial layer exists. [in the initial stage of film formation] On the other hand, with this invention medium, they are the crystal structure of Co65Cr35 film, and Co76Cr19Ta5. Since the membranous crystal structure is very near, the structure perpendicular magnetic anisotropy films excelled [structure] in the strong crystal stacking tendency of a perpendicular anisotropy from the initial stage of film formation is formed.

[0056] Record reproducing characteristics were evaluated for these media like the example 1. The recording density dependency of medium S/N of these media is shown in drawing 19 . this invention medium W is conventionally excellent in medium S/N in all recording density compared with Medium X. This inclination will become stronger if recording density becomes high.

[0057] Also in high recording density called 400KFRPI(s), this invention medium W has conventionally good about 8dB property compared with Medium X. Therefore, the bird clapper turned out that it was easy to realize high-density record by using this invention medium.

[0058]

[Example 11] On the 3.5 inches glass substrate, 5 micrometers of NiP soft-magnetism films of 80Oe were produced by the spatter. On this NiP soft-magnetism film, they are 0.1 micrometers of Cr films, and aluminum 2O3. 0.2 micrometers of films, 0.5 micrometers of Sendust films, and aluminum 2O3 0.2 micrometers of films, Co1-x Crx 50nm, and Co82Cr15Ta3100(at%) nm were formed one by one. here -- X -- 0.2, 0.25, 0.4, 0.5, and 0. -- it was made to change with 6 and 0.7 Thus, the produced this invention medium was used as media Y1-Y6. For comparison, 0.5 micrometers and Co82Cr15Ta3100(at%) nm were formed for the Sendust film one by one on the 3.5 inches glass substrate. Thus, the medium was used as Medium Z conventionally which was produced.

[0059] In order to investigate the crystal stacking tendency of these media, it asked for the half-value width (**theta50) of the rocking curve of a hcp (002) peak like the example 10. The result is shown in drawing 20 . The result of medium S/N in recording density 250kFRPI obtained by evaluating record reproducing characteristics like an example 1 in these media was also doubled and shown in drawing 20 .

[0060] Conventionally, there are eight media Z to **theta50 being 8 times by this invention medium Y1 (x= 0.2) with few Cr contents, and the improvement effect is not seen. It turns out that it becomes 2 to 5 [conventionally smaller than a medium] times from this invention medium Y2 (x= 0.25) by the medium Y5 (x= 0.6), and the stacking tendency is improving. However, by this invention medium Y6 (x= 0.7) with many Cr contents, since a CoCrTa film comes to be easy in a field like the usual record medium within Cr ground side, the amount of preferred orientation becomes bad rapidly. As a result of reflecting these crystal stacking tendencies, it turns out that this invention medium Y2 (x= 0.25) to the medium Y5 (x= 0.6) improves [5dB] from 3 rather than a medium conventionally also about medium S/N of recording density 250kFPI. Therefore, the bird clapper turned out that it was easy to realize high-density record by using this invention medium.

[0061]

[Effect of the Invention] Since the first soft-magnetism film which has the coercive force of 1-100Oe, the second soft-magnetism film which consists of a Sendust film, and perpendicular magnetic anisotropy films should be formed on the substrate at this order according to the vertical-magnetic-recording medium according to claim 1 to 6, the instability of the magnetic domain of the second soft-magnetism film is improvable with the first soft-magnetism film. Therefore, the noise figure in high recording density can be improved.

[0062] According to the vertical-magnetic-recording medium according to claim 2, a substrate is aluminum alloy substrate and the coercive force of 1-100Oe can be easily given to a NiP film by the method of heat-treating and carrying out magnetization by being the NiP film with which the first soft-magnetism film was formed on aluminum alloy substrate.
[0063] According to the vertical-magnetic-recording medium according to claim 3, since Cr film should be inserted between the first soft-magnetism film and the second soft-magnetism film, the adhesion force of the first soft-magnetism film and the second soft-magnetism film can be increased with Cr film. Therefore, mechanical endurance can be improved.
[0064] According to the vertical-magnetic-recording medium according to claim 4, since the oxide film should be inserted in the upper and lower sides of the second soft-magnetism film, respectively, the second composition change or composition distribution of a soft-magnetism film can be suppressed by the oxide film. Therefore, an envelope property can be improved while being able to improve the noise figure in high recording density more.
[0065] Since the perpendicular stacking tendency of perpendicular magnetic anisotropy films improves by inserting the perpendicular ground film containing CoCr directly under perpendicular magnetic anisotropy films according to the vertical-magnetic-recording medium according to claim 5 or 6, the noise figure in high recording density can be improved more.

[Translation done.]